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YOUNG & JATLOW
2300 N STREET, N. W.
SUITE 600
WASHINGTON, D. C. 20037

DAVID C. JATLOW
FRANCIS L. YOUNG*
*ADMITTED IN TEXAS

TELEPHONE
(202) 663-9080
TELEFAX
(202) 331-8001

March 20, 1998

Ms. Magalie Roman Salas, Secretary
Federal Communications Commission
1919 M Street, N.W.
Washington, D.C. 20554

In re: **Ex Parte Communication**
Ericsson Inc.
CC Docket 94-102

Dear Ms. Salas:

On March 19, 1998, representatives of Ericsson Inc. met with Ron Netro and Won Kim of the Wireless Telecommunications Bureau regarding issues related to the above-referenced proceeding. Specifically, Ericsson Inc. discussed the Commission's interpretation of how a carrier meets the Phase II ALI RMS accuracy requirement. It requested that the Commission revert to the interpretation in the July 26, 1996 *Report and Order* in CC Docket No. 94-102 that the location of a 911 caller must be located within a radius of 125 meters in 67% of all cases.

Ericsson also prepared and submitted to Mr. Netro and Ms. Kim a paper entitled *E911 ALI Accuracy Requirement* Two copies of this letter and the paper mentioned herein are being submitted for inclusion in the record of this proceeding. Copies of this letter and attachment are also being hand delivered this day to Mr. Netro and Ms. Kim.

Respectfully submitted,

David C. Jatlow
Counsel for Ericsson Inc.

cc: Mr. Ron Netro
Ms. Won Kim

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E911 ALI Accuracy Requirement

1 Recommendation

The Commission should re-evaluate its interpretation of the Phase II ALI accuracy standard established in the December 1997 Memorandum Opinion and Order which reconsidered the wireless E911 rules. The Commission should specifically revert to the original interpretation set forth in the Report and Order in Docket No. 94-102 which expressly stated that the location of a 911 caller must be located within a radius of 125 meters in 67% of all cases. As will be described in more detail below, failure to revisit this issue could result in the inability of covered carriers to comply with Section 20.18(e) by October 1, 2001.

2 Introduction

In 1996, the Commission adopted a Report and Order which required certain designated CMRS carriers to provide Automatic Number Information ("ANI") and Automatic Location Identification ("ALI") information for mobile units accessing carriers' wireless systems. The Phase I rules, among other things and under certain conditions, require licensees subject to the wireless 911 rules to provide the telephone number of the mobile unit as well as the cell site location or sector within which the mobile unit is located. The Phase II rules, which currently are due to become effective no later than October 1, 2001, require covered CMRS carriers to provide the location of a mobile unit by latitude and longitude within a radius of 125 meters using RMS methodologies.

Until the Commission released its Memorandum Opinion and Order just a few months ago, and based on the Commission's own statements, Ericsson as well as many manufacturers and service providers, interpreted the 125 meter RMS rule to mean that this level of accuracy had to be met for at least 67% of all wireless 911 calls. However, in the December, 1997 Memorandum Opinion and Order the Commission changed its interpretation by stating that the Phase II 125 meter RMS accuracy requirement had to be met for all wireless 911 calls.

ERICSSON INC.
Public Affairs
1634 I Street, NW, Suite 600
Washington, D.C. 20006-4083

Telephone
202-783-2200

FAX
202-783-2206

3 Discussion on ruling

In its July 26, 1996 *Report and Order* adopting rules for wireless E911 services, the FCC promulgated new Section 20.18(e) which requires "covered" CMRS carriers to provide mobile unit location information to PSAPs within a 125 meter radius:

As of October 1, 2001, licensees subject to this section must provide to the designated Public Safety Answering Point the location of a 911 call by longitude and latitude within a radius of 125 meters using root mean square techniques. (47 CFR 20.18(e))

Though not in the rules itself, the FCC provided additional interpretation of Section 20.18(e) in the text of its *Report and Order*. With regard to the 125 meter root mean square ALI language, the FCC stated the following:

In light of these considerations, we adopt a requirement pursuant to which covered carriers must achieve the capability to identify the latitude and longitude of a mobile unit making a 911 call, within a radius of no more than 125 meters in 67 percent of all cases. The degree of accuracy will be calculated through use of Root Mean Square methodology. For purposes of complying with this requirement, covered carriers shall attempt to invoke the equipment and facilities they have deployed to determine mobile unit location in each case in which a 911 call transits their system. For purposes of applying the RMS methodology, the level of accuracy achieved by the carrier shall be calculated based upon all 911 calls originated in a service area in which the carrier is required to supply Automatic Location Identification to PSAPs. A covered carrier shall be required to demonstrate, upon request made by the PSAP, that its ALI system performs in compliance with the requirements established in this Order. (FCC 96-264 at Para. 71)

...the rule will require cellular, broadband PCS, and geographic area SMR licensees to upgrade their equipment so that: Emergency service providers will be sent the location of the 911 caller within a radius of 125 meters by longitude and latitude in 67 percent of all cases. These upgrades will require engineering and construction work on switches, protocols, and network architectures. (FCC 96-264, Appendix III, (5))

Relying on the plain meaning of the foregoing language, numerous hours of engineering time has been devoted to developing ALI solutions based on the assumption that carriers must achieve the capability to identify the latitude and longitude of a mobile unit to make a 911 call, within a radius of no more than 125 meters in 67% of all cases.

Because the Commission's "interpretation" of the 125 meter Phase II ALI rule was not included in the text of Section 20.18(e) itself, and while working to

develop technology to comply with the Phase II wireless E911 requirements, certain parties sought reconsideration of Section 20.18(e) asking the FCC to clarify its applicability in general and specifically to include in the FCC's rules the "67%" language. For example, in ex parte presentations made in the Reconsideration proceeding of the wireless E911 rules, Motorola wrote that "125m at 67% goal is achievable." Similarly, True Position told the FCC that "the rules should state that the accuracy requirement is 125 Meters for 67% of 911 calls." Though not part of the FCC's Reconsideration proceeding, at the CTIA E911 Workshop in Location Technology, the Telecommunications Industry Association's TR 45.2 Wireless Emergency Services Task Group submitted a contribution which clearly stated that Phase II requirements must "provide initial latitude and longitude of a caller within 125 m RMS (67% of the time)."

Notwithstanding the foregoing, in its December 23, 1997 *Memorandum Opinion and Order* reconsidering the initial wireless E911 rules, the FCC significantly changed its interpretation of the 125 meter RMS ALI rule. In the *Memorandum Opinion and Order* the FCC stated:

With respect to the Phase II ALI accuracy standard of 125 meters using RMS methodologies, the I-95 Coalition argues that clarification of the accuracy requirement might be necessary, indicating that some parties might interpret the requirement as being met if the carrier is able to locate 67% of the mobile units with 100% accuracy or some combination of located users and levels of accuracy. Based on their concerns that carriers might interpret the requirement as to requiring deployment in rural areas, the I-95 Coalition emphasizes the need for position location in rural as well as urban environments.

Section 20.18(e) of the Commission's rules requires that covered carriers identity the latitude and longitude of a mobile unit making a 911 call, within a radius of no more than 125 meters using RMS measurement. Based upon the Consensus proposal, we determined in the E911 First Report and Order that the RMS methodology should be applied to reach this level of accuracy in identifying the location of each 911 call. To comply with the rules, therefore, we stated that a carrier must deploy the ALI technology in its service area and determine mobile unit location in each case in which a 911 call transits its system. To the extent that the discussion in the E911 First Report and Order may be unclear, we clarify that, as of October 1, 2001, licensees subject to this section must provide to the designated PSAP the location of all 911 calls by longitude and latitude such that the RMS is 125 meters of less, which would represent approximately a 67 percent to 75% probability that the reported location would be within a 125 meter radius of the caller's actual location. This would include 911 calls made by roamers in a carrier's service area. Therefore, we expect that any Phase II ALI technology deployed by a

carrier, whether it is a network-based approach, or any other approach, would satisfy this requirement. (FCC 97-402, Para. 125-126)

The FCC modified the text of Section 20.18(e) to read as follows:

Phase II Enhanced 911 services. As of October 1, 2001, licensees subject to this section must provide to the designated Public Safety Answering Point, the location of all 911 calls by longitude and latitude such that the accuracy for all calls is 125 meters or less using a Root Mean Square (RMS) methodology. (FCC 97-402, Appendix B)

Ericsson and many others in the industry relied on the Commission's interpretation of Section 20.18(e) since the *Report and Order* was released 18 months ago. It has relied on the specific language that location within 125 meters 67% of the time was the legal requirement for covered CMRS carriers. The clarification of Section 20.18(e) established in the recently released *Memorandum Opinion and Order* is a substantial change in interpretation. The change is so radically different than the interpretation originally provided, that there are many in the industry that do not believe it is technically feasible to develop Phase II ALI systems that will meet the most recently issued interpretation. Note that even with the first interpretation it still remains to be proven that such requirements can be met. As a result, Ericsson suggests that the Commission re-evaluate the interpretation of the Phase II ALI accuracy standard established in the *Memorandum Opinion and Order* and revert to the original interpretation that covered carriers be required to provide "...the location of the 911 caller within a radius of 125 meters by longitude and latitude in 67% of all cases."

4 Ericsson Interpretation up to December 1997

In [1], #10 under section "Executive Summary of Commission Actions, Report and Order", it is stated that "... Under Phase II, not later than five years after ..., covered carriers are required to achieve the capability to identify the lat. and long. of a mobile unit making a 911 call, within a radius of no more than 125m in 67 percent of all cases."

Our exact interpretation of that is the following. Let $\hat{\mathbf{x}}$ be the reported (estimated) position vector and $\mathbf{x}$ be the true position vector. The Circular Error Probability, CEP, has then to obey:

$$CEP = P\left(\|\mathbf{x} - \hat{\mathbf{x}}\| \le 125\text{m}\right) \ge 67\% \qquad (1)$$

The CEP measurement discards the significance of errors beyond the 125 m limit.

5 FCC Clarification December 1997

In [2], #126 it says "... To the extent that the discussion in the E911 First Report and Order may be unclear, we clarify that, as of October 1, 2001, licensees subject to this section must provide to the designated PSAP the location of all 911 calls by long. and lat. such that the RMS is 125 m or less (*), which would represent approx. a 67% to 75% probability that the reported location would be within a 125 m radius of the caller's actual location. This would include 911 calls made by roamers in a carrier's service area...", with the footnote 325 at (*) reading essentially that errors larger than 125m would be more tolerable if they are relatively small.

To support the request that errors larger than 125m would be more tolerable if they are relatively small, the error criteria was specified to the RMS criterion:

$$RMS = \sqrt{E\left[\left\|\mathbf{x} - \hat{\mathbf{x}}\right\|^2\right]} \leq 125\text{m} \tag{2}$$

The final rules unambiguously explains that a RMS measure is to be used (see [2], App. B, FINAL RULES, 20.18 '911 Service', (e) Phase II Enhanced 911 Services):

"As of October 1, 2001, licensees subject to this section must provide to the designated PSAP the location of all 911 calls by long. and lat. such that the accuracy for all calls is 125m or less using a Root Mean Square (RMS) methodology."

6 RMS versus CEP

The criteria (1) and (2) are not equivalent.

For example, assume the Gaussian error distribution:

$$\mathbf{x} - \hat{\mathbf{x}} \in \mathrm{N}\left(0, \mathbf{T}\Delta\mathbf{T}^{\mathrm{T}}\right) \tag{3}$$

where T is orthonormal 2*2 coordinate transformation matrix and

$$\Delta = \begin{bmatrix} \sigma_x^2 & 0 \\ 0 & \sigma_y^2 \end{bmatrix} \tag{4}$$

The curves of equal probability are ellipses with axis lengths σ_x and σ_y respectively. They depend on the measurement geometry etc.

It is straightforward to obtain:

$$RMS = \sqrt{E\left[\left\|\mathbf{x} - \hat{\mathbf{x}}\right\|^2\right]} = \sqrt{\sigma_x^2 + \sigma_y^2} \tag{5}$$

In the special case $\Delta = \sigma\mathbf{I}$, *i.e.*, circularly symmetric distribution, we get:

$$RMS = \sqrt{2}\sigma \tag{6}$$

$$CEP(r) = P\left(\|\mathbf{x} - \hat{\mathbf{x}}\| \le \mathrm{r}\right) = 1 - e^{-\frac{r^2}{2\sigma^2}} \tag{7}$$

and thus, the 67% CEP radius:

$$r_{CEP=67\%} = \sigma\sqrt{2\log\left(\frac{1}{1-0.67}\right)} = 1.49\sigma \tag{8}$$

Hence, a 125 m RMS limit would correspond to:

a) a 67% CEP radius of 131 m or

b) a 63% CEP radius of 125 m.

In the general case (non-circularly symmetric distribution), the CEP radius is difficult to calculate analytically. After studying such non-circular distributions we found that RMS and 67% CEP are practically equivalent for normal distributed errors. For other error distributions, however, the two requirements can become very different as being described in the next sections.

7 Our Concern

We feel it is inevitable that a small percentage of the ALI measurements will fail (see Section 8). These failures will generate a fraction of position estimates with large errors, so called "outliers". Even if the majority of the ALI measurements is close to Gaussian distributed (3), these small fraction of "outliers" will have a dramatic effect on the RMS requirement. In Section 9, a few examples is provided that illustrate this effect. In Section 10, a simple example is provided to further illustrate the problem with a RMS requirement.

As can be noted, even at very small ALI failure percentages the RMS requirement turns out to be impossible to fulfill.

8 Why will the ALI measurements sometimes fail?

In wireline communication one designs for a certain quality of service, usually specified as a low blockage level. The blockage is caused by resource limitations in the system. A typical maximum blockage level is 2% during peak traffic.

In wireless communication, a crucial aspect must also be considered — the radio coverage. In practice, it is impossible to always guarantee radio coverage, *i.e.*, a fraction of calls will not have adequate radio coverage to

obtain a satisfactory service. This fraction is sometimes referred to as outage. A typical outage level for wireless service during peak traffic is 10% or better.

Further, since mobility is normally required in wireless system, the limitation of radio coverage will result in a fraction of the calls being disconnected prematurely. This is sometimes referred to as dropped call rate. Unfortunately, this will also occur in 911 calls.

ALI in wireless communication systems can be introduced with different methods. These methods can be divided into the following categories:

1. Time measurements, *e.g.*, TOA, TDOA, round-trip delay
2. Angle measurements, *e.g.*, AOA
3. Combination of 1 and 2
4. GPS equipped terminals

In practice, all wireless ALI methods will have a slightly different radio coverage than the communication system.[1] For GPS (category 4), this difference is obvious. For category 1 and 2, measurements are required between more locations than to the serving base station site resulting in a slightly lower radio coverage for ALI.

In practice, there will therefore always be a fraction of occurrences when there is radio coverage for a 911 call, but not for the ALI method. This fraction must of course be minimized, but it is unreasonable to always expect radio coverage for the ALI method.

9 Example 1

As an illustration, assume that the error of the location estimate is normal distributed as in eq. (3), with a nominal 67% CEP radius of 125 m. Assume further that there is a small probability, $p << 1$, that there is no radio coverage for the ALI method. In these cases the ALI is assumed to deliver the cell id., *i.e.*, the center of the serving cell. Thus, with a uniform density of mobiles, we consider the location estimate in case of failure to be uniformly distributed within the circular disc $\|\mathbf{x} - \hat{\mathbf{x}}\| \le R$.

The figures below show the effective RMS and 67% CEP radii for different failure rates p in environments with four different cell radius: 1000m, 2500m, 5000m and 10000m.

[1] The only method where the radio coverage matches is a special case of 3 called single site location (SSL). Unfortunately, the SSL method is not reasonable to implement as the only ALI solution.

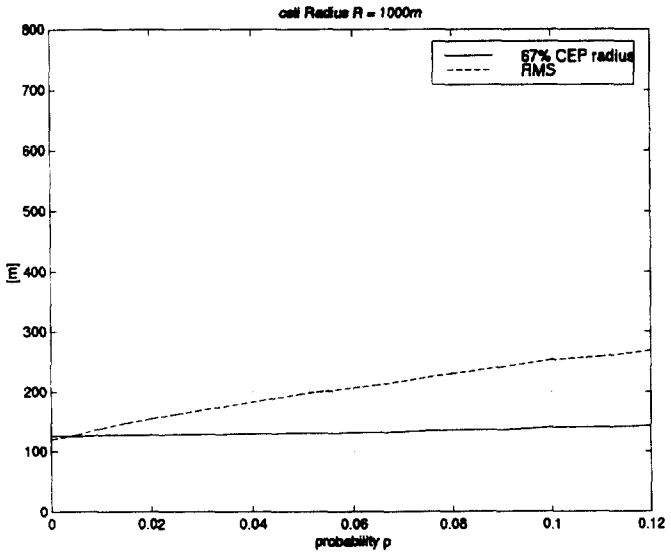

Figure 1: 1000 m Cell Radius

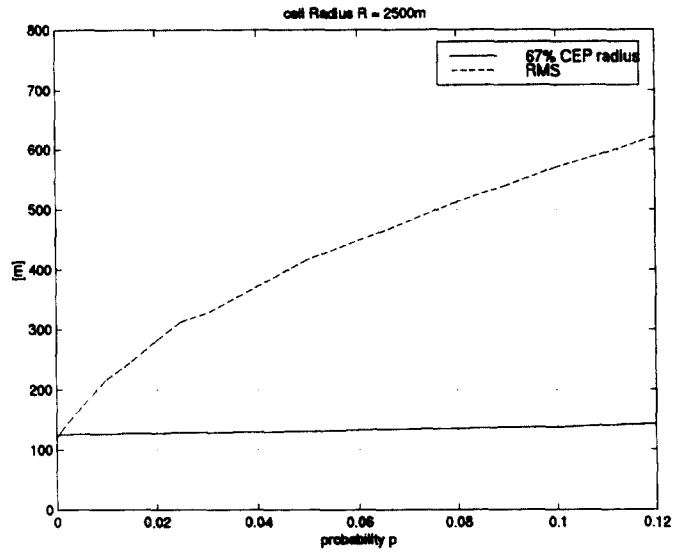

Figure 2: 2500 m Cell Radius

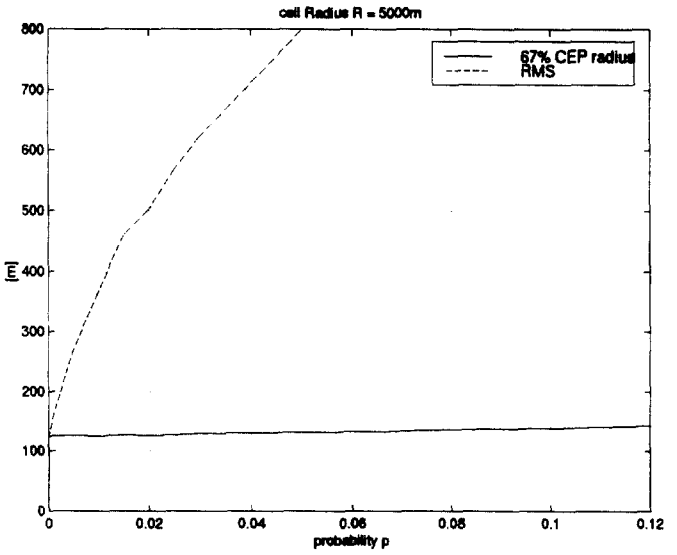

Figure 3: 5000 m Cell Radius

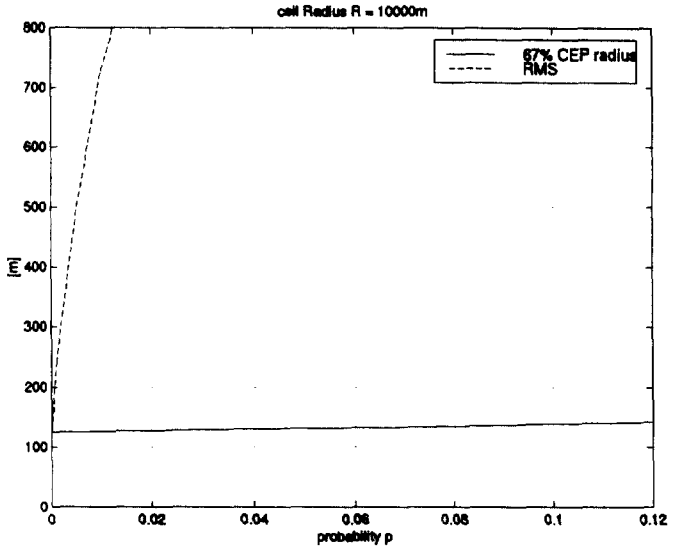

Figure 4: 10000 m Cell Radius

10 Example 2

Let assume that you have an ALI method with perfect accuracy, *i.e.*, one that provides 0 m accuracy. Using the same assumptions as in example 1, the RMS error in an environment with cell radius of R can be calculated as:

$$RMS = R\sqrt{\frac{p}{2}} \tag{9}$$

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Hence, even with a *perfect accuracy* and only 1% failure rate, it is *impossible* to fulfill a 125 m RMS requirement in a cell larger than 1770 m. A 5% failure rate, would push this limit down to 790 m.

11 Measurement

One very simple reason to prefer the 67% criterion to the rms criterion is in its validation. With the 67% criterion all a dispatched unit would have to do is to report if the indicated position was roughly within 125m or not. With such data the 67% criterion could be validated. In order to validate a rms criterion each dispatched unit would have to figure out exactly where the origin of a the given position was and then exactly measure the distance to the actual position. This would result in values such as 132m, 87m etc. This measurement would probably take a longer time then their original business and would probably also require hiring extra personal to deal with this particular task. When sufficient values had been collected the true rms value could be estimated.

12 Conclusion

In our view, the inevitable "outliers" will result in the RMS requirement being unreasonable even at very small ALI failure percentages. We therefore suggest to define the 125 m accuracy requirement as the maximum 67% CEP radius.

13 References

[1] Federal Communications Commission (FCC), "Report and Order and Further Notice of Proposed Rulemaking", *FCC 96-264,* July 1996.

[2] Federal Communications Commission (FCC), "Memorandum Opinion and Order", *FCC 97-402,* December, 1997.